Claims

What is claimed is:

1. An apparatus for nondestructively measuring localized diffusible hydrogen concentrations in an object, comprising:

a sensor housing having a hydrogen inlet;

a sensor positioned within the sensor housing, the sensor including a hydrogen sensing layer located adjacent the hydrogen inlet and comprising chemochromic material that reacts with hydrogen causing a property change in the chemochromic material; and

a sealing member connected to the sensor housing proximal to the hydrogen inlet, wherein the sealing member is sealably engageable with the object to define a sample area on the object from which hydrogen is allowed to diffuse and wherein the sealing member and the sensor housing define a sample volume between the sample area and the hydrogen inlet.

2. The apparatus of claim 1, further including a hydrogen monitoring assembly operably connected to the sensor and adapted for measuring the property change in the hydrogen sensing layer and for determining a diffusible hydrogen concentration based on the measured property change, the sample area, and the sample volume.

3. The apparatus of claim 1, wherein the property change is a change in optical transmission properties based on concentrations of the reacted hydrogen and the sensor includes an optical fiber for directing transmitted light to and reflected light from the sensing layer.

4. The apparatus of claim 3, wherein the chemochromic material is selected from the group consisting of transition metal oxides.

5. The apparatus of claim 4, wherein the chemochromic material is tungsten trioxide, molybdenum trioxide, yttrium dihydride, or lanthanum dihydride.

6. The apparatus of claim 5, wherein the sensing layer is connected to the optical fiber by evaporative deposition, whereby the sensing layer is a porous, low-density film.

7. The apparatus of claim 3, wherein the sensor further includes a reflector layer adjacent the sensing layer for reflecting the transmitted light passing through the sensing layer back through the sensing layer and the optical fiber as the reflected light.

8. The apparatus of claim 7, wherein the reflector layer is interposed between sensing layer and the sample volume and comprises a material that adsorbs molecular hydrogen on a surface exposed to the sample volume and releases the adsorbed molecular hydrogen into the sensing layer.

9. The apparatus of claim 8, wherein the material comprising the reflector layer is palladium or platinum.

10. The apparatus of claim 9, wherein the reflector layer has a thickness in the range of about 3 to about 30 nanometers.

11. The apparatus of claim 7, further including a light source for providing the transmitted light to the optical fiber and a reflectance measuring device for receiving from the optical fiber the reflected light and for processing the reflected light to calculate an amount of diffusible hydrogen diffusing from the sample area of the object.

12. The apparatus of claim 11, wherein the light source is a laser configured for emitting the transmitted light as collimated light.

13. The apparatus of claim 12, wherein the transmitted light has a wavelength of about 850 nanometers and an intensity selected from the range of about 1 to about 3 microWatts.

14. An apparatus for use in measuring diffusible hydrogen concentrations in a selectable portion of a structure, comprising:

a housing having a first opening adapted for being operatively and selectively connected to a selected portion of the structure, whereby hydrogen evolving from the selected portion is captured within the housing; and

a hydrogen sensor mounted in the housing so as to be exposed to the captured evolving hydrogen from the selected portion, wherein the hydrogen sensor comprises material that changes optical properties based on concentration of the captured evolving hydrogen.

15. The apparatus of claim 14, wherein the housing defines a sample area on the selected portion of the structure and defines a sample volume adjacent the hydrogen sensor wherein the captured evolving hydrogen is sealably contained, and wherein the diffusible hydrogen concentrations of the selected portion of the structure are measurable based on the sample area, the sample volume, and the changes in the optical properties of the hydrogen sensor.

16. The apparatus of claim 15, further including an optical fiber for directing light to and away from the hydrogen sensor, the optical fiber being mounted within the housing with a first end adjacent the hydrogen sensor and a second end proximal to a second opening of the housing.

17. The apparatus of claim 16, further including a reflector mounted in the housing adjacent the first opening and interposed between the hydrogen sensor and the sample volume,

wherein the reflector comprises a material that adsorbs and releases molecular hydrogen and that reflects light.

18. The apparatus of claim 17, further including a hydrogen monitoring assembly operably connected to the second end of the optical fiber and adapted for transmitting light to the second end of the optical fiber, for receiving a portion of the transmitted light that passes through the hydrogen sensor and is reflected by the reflector, and for determining a diffusible hydrogen concentration of the selected portion of the structure based on the received portion of the transmitted light.

19. A method for measuring a diffusible hydrogen concentration in an object, comprising:

selecting a portion of the object from which to obtain a diffusible hydrogen concentration measurement;

sealably mounting a hydrogen sensor assembly on the selected portion of the object, the sensor assembly including a housing that defines a sample area on the selected portion from which hydrogen is allowed to evolve and a sample volume in which the evolving hydrogen is captured, wherein the sensor assembly further includes a hydrogen sensor comprising a hydrogen-reactive, chemochromatic material mounted within the housing adjacent the sample volume;

allowing the hydrogen sensor to react with the captured evolving hydrogen for a predetermined sample time;

measuring an amount of change in a physical property of the hydrogen sensor; and

calculating the diffusible hydrogen concentration in the selected portion of the object based on the measured amount of change in the physical property of the hydrogen sensor.

20. The method of claim 19, wherein the predetermined sample time is selected from the range of 10 to 30 minutes.

21. The method of claim 19, wherein the selected portion is a welded joint, and further including prior to the mounting, waiting a cooling time period and using the calculated diffusible hydrogen concentration and the cooling time period to determine an initial diffusible hydrogen concentration in the selected portion.

22. The method of claim 19, wherein the physical property is optical transmissivity of the hydrogen sensor and the sensor assembly further includes a reflector positioned within the housing so as to be interposed between the sample volume and the hydrogen sensor, the

reflector being configured for reflecting light passing through the hydrogen sensor back through the hydrogen sensor.

23. The method of claim 22, further including operatively connecting a reflectance monitoring device including a light source and a light signal detector to the sensor assembly, and wherein the measuring includes operating the reflectance monitoring device to transmit a light signal from the light source to the hydrogen sensor and to receive a reflected portion of the light signal with the light signal detector.

R.126 24 ~~25~~. The method of claim 23, further including connecting a signal analyzer to the light signal detector for receiving a signal from the light signal detector based on the received reflected portion, and wherein the calculating of the diffusible hydrogen concentration is completed in part by operating the signal analyzer to compare the signal from the light signal detector and the transmitted light signal from the light source.

25 ~~26~~. The method of claim 19, further including calibrating the hydrogen sensor assembly to create calibrating information, and wherein the calculating of the diffusible hydrogen concentration is based on the calibrating information.

26 ~~27~~. The method of claim 26, the calibrating being completed prior to the mounting of the hydrogen sensor assembly based on measurements of the sample area and the sample volume and based on collected calibration testing information.

27 ~~28~~. The method of claim 26, the calibrating being completed after the mounting of the hydrogen sensor on the object and including injecting a selected amount of hydrogen into the sample volume, allowing the selected amount of hydrogen to react with the hydrogen sensor for a predetermined calibration time, and measuring the amount of change in the physical property of the hydrogen sensor.